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PUMPING CURD AND WHEY
IN MAKING
CHEDDAR AND GRANULAR CHEESE

By
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CONCLUSIONS

This study, designed to assist cooperative and other cheese plants, indicates that there are savings in making cheddar cheese by pumping curd and whey. However, savings are even greater when this method is used to make granular cheese. Most of these additional savings are due to the fact that less labor is required to manufacture granular than cheddar cheese.

For plants making 6 or more vats of cheese per day, the curd sink and pump method has possibilities for reducing manufacturing costs for both cheddar and granular cheese as shown in experiments covered in this report. When a plant is organized for curd sink operation, and the cheese maker has his crew's work schedule systematized, probably more labor can be eliminated than is shown in the comparisons given. The study shows that curd can be pumped and curd sinks used without injuring the curd.

Because greater savings can be made in manufacturing granular than cheddar cheese, the possibility of developing a closer knit granular cheese that would resemble cheddar cheese in texture might well be considered. An experiment in which a bench vise was used to press granular cheese indicated that this could be done by applying greater pressure to cheese hoops than is possible with conventional equipment.

Continued study is needed to determine the proper pressure and to develop uniform time schedules and techniques. When the product is put on the market in sufficiently large quantities, a grading code for granular cheese as such should be developed. Experimental work shows the feasibility of making granular cheese insofar as the engineering aspects are concerned but further research will be needed before techniques can be developed that will result in uniform quality of product.

PUMPING CURD AND WHEY IN MAKING CHEDDAR AND GRANULAR CHEESE

By

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Labor accounted for at least 50 percent of the cost of manufacturing cheddar cheese in factories on the west coast according to a preliminary study made in 1949. Thus it appeared that a reduction of labor requirements offered the greatest opportunity for reducing the total cost, by (1) replacing manual labor, where possible, with mechanical methods or (2) arranging equipment to centralize related operations to minimize manual transportation of curd or cheese.

NATURE OF THE STUDY

This study was made in a cooperative cheese factory to determine whether curd in whey could be transferred by pumping without injuring its quality. When the project was planned in 1949, no references were found dealing with the pumping of curd and whey. Cheese makers and technicians in cheese plants, cheese machinery manufacturers, and State college officials were asked whether pumping would affect the quality of the curd. None knew of experiments in which pumps had been used and while they would not make a positive statement, they could think of no reason why pumping should injure the curd. However, when starting these experiments about a year later it was learned that a cheese manufacturer was then experimenting with pumping curd.

A second objective was to determine whether operational time could be reduced by completing the process of cheddaring in a curd sink and obtain comparable quality with that made entirely in a standard cheese vat.

Some of the basic questions the study was designed to answer were:

1. Can comparable quality be obtained by pumping curd and whey in making cheddar cheese?
2. Can comparable quality be obtained by cheddaring cheese in a curd sink?

Note: This study was made under the general supervision of Donald E. Hirsch, Dairy Section, Cooperative Research and Service Division.

Credit is due W. M. Hurst, Senior Agricultural Engineer, B.P.I.S.A.E., for assistance in preparing this report.

Acknowledgment is made of cooperation in this study of the Dairyland Cooperative Association, Juneau, Wis.; Damrow Brothers Company, Fond du Lac, Wis.; and the Waukesha Foundry Company, Waukesha, Wis.

3. Can the investment in equipment be reduced by the curd sink method?
4. Can labor costs be reduced by the curd sink method?
5. What advantages, other than saving labor, can be obtained by using pumps and curd sinks in plants making 6 or more lots of cheese per day?
6. How do labor and equipment requirements for making granular cheese in curd sinks compare with the conventional cheddar cheese?

Arrangements were made with a cheese equipment manufacturer for the loan of cheese vats with the necessary accessories; with a manufacturer of a measuring type pump; and with a cooperative cheese factory for space, facilities, personnel, and supplies to carry on this study.

The equipment used consisted of:

- 1 - 900-pound standard cheese vat with agitating unit mounted on an angle iron stand secured to outside corners of vat.
- 1 - 900-pound standard cheese vat with agitating unit mounted as above but adapted for operation as a curd sink.
- 1 - tinned frame placed inside of liner to support drain tray.
- 1 - tinned steel drain tray with semi-circular ends and bottom perforated with 1/16 inch holes spaced 1-3/16 inches apart.
- 1 - tinned steel drain tray with solid bottom pitched 1-inch from both sides to center perforated drain 8 inches wide.
- 1 - multi-speed rotary milk measuring pump with direct connected motor.
- 1 - standard 2-inch centrifugal milk pump with direct connected motor.
- 1 - lot of 2-inch standard sanitary milk pipe and fittings to inter-connect vat pump and curd sink.
- 1 - lot 1-1/2-inch standard sanitary milk pipe from pasteurized milk supply line to cheese vat and whey line from curd sink to whey tank feeding cream separator.
- 1 - horizontal 3/8 inch curd knife.
- 1 - vertical 3/8 inch curd knife.

All the necessary supplies and equipment such as dial scale on castors, cheese hoops and salt and cheese presses were furnished by the cooperative. The assistant cheese maker was assigned by the cooperative to manufacture the experimental cheese.

Two varieties of American cheese were made in this experiment -- cheddar and granular.

MAKING CHEDDAR CHEESE

Cheese making requires sufficient time for bacteria in the starter and enzymes in the rennet to produce the type of cheese desired. Other requirements, such as temperature and period of time between operations, have been standardized by commercial, State, and Federal agencies and are based on good quality milk. Since the composition and bacteria count of milk received at a plant vary, the schedule must be altered occasionally under customary plant operating conditions.

In making cheddar cheese the curd, after draining, is worked by hand in the cheese vat. Two lots of cheddar cheese were made with a curd sink and pump to determine whether this method offered advantages in labor and equipment required. The same cheese maker made both lots of cheese and used the same techniques in observing the progress and condition of the curd as he used in making cheddar cheese with the customary equipment.

In making the experimental lots of cheddar cheese, the curd together with the whey was pumped to the sink from the vat at the time the cheese maker would normally start draining the vat. The draining and cheddaring operations were then performed in the sink in practically the same manner as they would have been in the vat. The curd was milled, salted, and hooped in the customary way.

Two types of pumps were used. For one lot, a rotary pump of the type generally used with short-time pasteurizers was used. In the other lot, a regular centrifugal milk pump was used. When the curd was cut with a single application of either 1/4 or 3/8 inch curd knives, no evidence of curd dust (minute particles of curd) was found in whey pipe-lines or curd sinks whether either pump was used. However, when curd knives were applied more than once (which is not customary), the slivers made by the second cutting showed up as curd dust in the sink and in the discharge line from the whey pump to the whey storage tank. The rotary pump deposited one tablespoon of curd dust in the whey pump discharge line, and the centrifugal pump deposited five-eighths of a cup of curd dust. More curd dust may have been produced and carried over than was collected. However, only when the curd was cut twice was any curd dust found.

Judging from subsequent examination of the two lots of cheddar cheese, pumping curd and whey from a cheese vat to a curd sink and the use of a sink for cheddaring have no effect on the quality of cheddar cheese. However, the use of the equipment reduced the total time required in making cheese by 46 minutes. This time reduction of about 10 percent was due largely to faster draining in the curd sink than in regular vats. The perforated bottom of the tray in the sink enabled the whey to drain off immediately and not become entrapped under slabs of curd as is common when cheddared on the solid bottom of a regular cheese vat.

Curd sinks used in former years were built with solid tinned steel bottoms sloping from the sides of the liner to a perforated strip in the center of the sink. The inside depth ranged from 10 to 12 inches.

The experimental sink had a flat all-perforated stainless steel bottom set inside a standard type cheese vat resting on a tinned angle iron frame to permit vat bottom to carry whey to its outlet.

The hand operations in matting, cheddaring, and milling can be performed with less effort in a curd sink than in a regular cheese vat. While the height of curd sinks and cheese vats from the top rail to the floor are the same, the depths from the top rail to the bottom of the liner are 11 to 13 inches compared with 24 to 26 inches in standard cheese vats.

Tables 1 and 2 show the periods of time vats are actually in use to convert milk into cheddar cheese from the time the starter is added to warm milk until the hoop containing the finished cheese is put into the cheese press for final pressing. Labor is required for certain manual operations during this conversion at certain times for the advancement of the process. However, these tables do not indicate the additional labor required for setting up equipment preparatory to starting the processing, removing the previous day's make from presses, and transporting cheeses to wrapping rooms, to wash machinery and accessories, and to empty cheese hoops in order to leave the plant and equipment clean and sanitary at the close of the day.

Table 2 shows the average of the time schedules for the experimental lots of cheddar cheese made in 1,000 pound vats but additional time must be allowed for the larger volume of 10,000-pound lots. These allowances are included in table 3 in order to permit comparison with data in table 1.

The period of time required for making cheddar cheese with and without curd sinks is graphically illustrated in figure 1 for a 6-vat plant. Each line represents a 10,000-pound cheese vat or sink. The time interval between filling successive vats is shown as 50 minutes. While this interval may vary from plant to plant, depending on the capacity of the pasteurizer, or the preference of the cheese maker, it answers the purpose for comparing the different methods of cheese making discussed. The first stage (or biological process) is the same for both the regular and the curb sink methods - a total of 3 hours and 22 minutes including 17 minutes for partially filling the vat prior to adding the starter.

The second stage (or mechanical process), as illustrated by figure 1 (A), takes 3 hours and 25 minutes which includes 5 minutes to rinse the vat to prepare it for re-use. Figure 1 (B) shows 3 hours 22 minutes for the biological process up to the time the curd and whey are ready to be drained into the curd sink. To make the cheese vat ready for re-use, 12 minutes draining time (pumping curd from cheese vat into curd sink) and 5 minutes rinsing time are shown in the dotted lines.

Table 1. - *Standard time schedule for manufacturing cheddar cheese*¹

Milk in vat - 10,000 pounds

Fat in milk - 3.5%

Pasteurized at 160° F. for 20 seconds

Acid in starter - .70

Steps in making	Time to start each step	Temperature	Acidity	Weights
Biological process -- phase 1.				
Add starter-----	8.15	86° F.	.16	70 lbs.
Add color-----	8.45	87	.16	10 oz.
Add rennet-----	9.00	88	.165	30 oz.
Coagulation-----	9.12	88	No test	
Cut curd-----	9.30	88	.10	
Steam on-----	9.45	88	.10	
Steam off-----	10.15	102	.105	
Settle curd-----	11.00	102	.12	
Ready to drain-----	11.20	102	.14	

Time for phase 1. 3 hours, 5 minutes

Mechanical process -- phase 2.

Start draining-----	11.20	102 F.	.14	25 lbs.
End dipping-----	11.30	102	.14	
Pack-----	11.45	101	.17	
Pile 2 high-----	12.30	96	.25	
Pile 3 high-----	1.00	93	.30	
Mill-----	1.30	91	.40	
Salt-----	1.50	89	No	
Start hooping-----	2.30	No	Test	
Finish hooping-----	2.40	test		

Time for phase 2. 3 hours, 20 minutes

Pressing Process -- phase 3.

Finish hooping-----	2.40	No tests		
Hoops in first press-----	2.50			
Dressing hoops-----	3.20			
Hoops in last press-----	3.40			

Time for phase 3. 1 hour, 0 minutes

Total time for all phases - 7 hours, 25 minutes

¹Price, W. V. Cheddar Cheese From Pasteurized Milk. University of Wisconsin, Bul. 464, 16 pp. Revised 1945.

Table 2. - Time schedule for making cheddar cheese in 1,000-pound experimental cheese vat and curd sink

Pounds of whole milk used-----	800		800	
Acidity and percentage fat in milk-----	.16	.36	-.18	3.5
Pasteurizing temperature and seconds held-----	163°F	16	163°F	16
Acidity and quality of starter-----	.76	Good	.83	Good
Operations	Lot 01151		Lot 01161	
Time and pounds starter added-----	7.54	12	7.50	12
Time and ounce color added-----	8.25	3/4	8.25	7/8
Time and ounce rennet added-----	8.35	2-3/4	8.32	2-3/4
Acidity and temperature of milk at rennet-----	.20	86°	.195	86°
Time and acidity at cutting curd-----	9.03	.125	9.02	.125
Time and acidity at steam on-----	9.18	.13	9.22	-.13
Time and acidity at steam off-----	9.45	.13	9.40	.13
Time and acidity at start draining-----	11.14	.165	11.20	-.18
Biological process	3 hours 20 minutes		3 hours 30 minutes	
Average time for both lots	3 hours 25 minutes			
Time and acidity at start pump-----	11.14	.165	11.20	-.18
Time and acidity at stop pump-----	11.19	.21	11.24	.23
Time start matting curd - acidity-----	11.24	.22	11.30	.23
Time start milling curd - acidity-----	12.24	.45	12.40	.43
Time and pounds of salt added-----	1.02	2-1/8	1.15	2-7/8
Time start hooping and acidity-----	1.37	.48	1.35	.46
Time finish hooping-----	1.42		1.40	
Mechanical process	2 hours 28 minutes		2 hours 20 minutes	
Average time for both lots	2 hours 24 minutes			
Time finish hooping-----	1.42		1.40	
Time hoop in first press-----	1.44		1.42	
Time hoop dressed-----	1.58		1.56	
Time hoop in last press-----	2.07		2.05	
Pressing process	25 minutes		25 minutes	
Average time for both vats	25 minutes			
Total time for all phases	6 hours 13 minutes		6 hours 15 minutes	
Average total time for all phases	6 hours 14 minutes			

Table 3. - *Adjustment of mechanical process shown in table 2 for 10,000-pound cheddar curd sink operation*

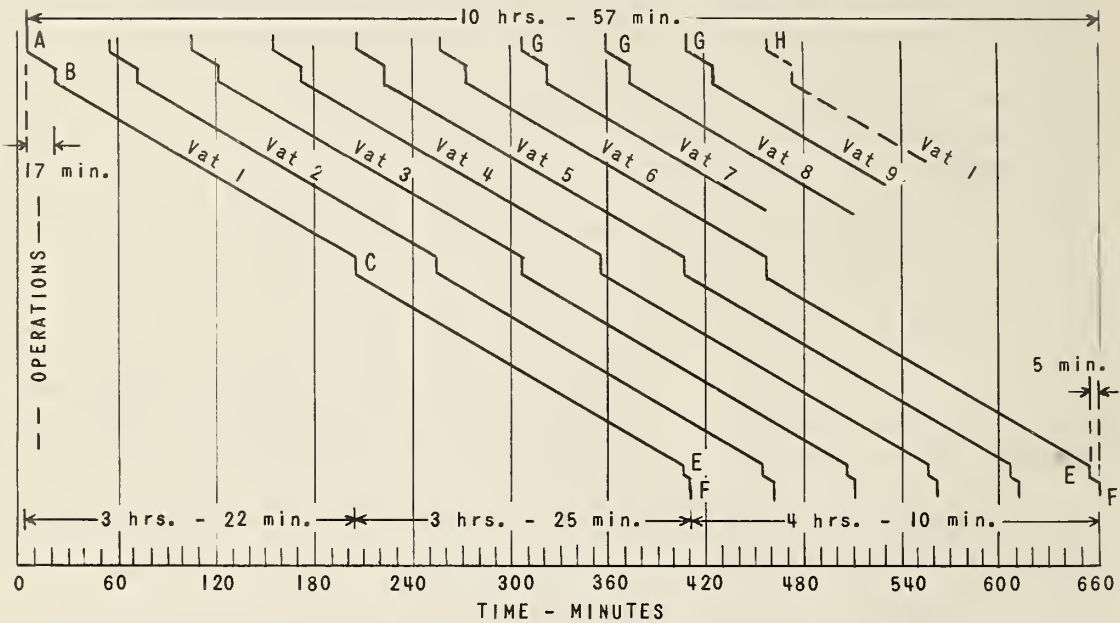
Biological process (phase 1) from table 1		3 hours 5 minutes
Mechanical process (phase 2)		
Start pump for draining		
Curd from vat-----	11. 20	
Pump stopped-----	11. 32	
Start matting curd-----	11. 35	
Start milling curd-----	12. 40	
Add salt-----	1. 17	
Start hooping-----	1. 44	
Finish hooping-----	1. 54	
Time phase 2		2 hours 34 minutes
Pressing process (phase 3)		
Finish hooping-----	1. 54	
Hoops in first press-----	2. 04	
Dressing hoops-----	2. 34	
Hoops in last press-----	2. 54	
Time phase 3		1 hour 0 minutes
Total time for all phases		6 hours 39 minutes

The mechanical time, figure 1 (B), shows 2 hours and 39 minutes for the period from the start to pump the curd and whey into the curd sink to the time the curd is hooped and 5 minutes for rinsing the sink to make it ready for re-use. The conventional method of making cheese, shown in figure 1 (A) requires a total of 10 hours and 57 minutes, compared with 10 hours and 11 minutes, figure 1 (B), for the pump and curd sink method. On that basis the curd sink method would require 93 percent as much time as the regular method, or a saving of 7 percent in operating time and labor cost.

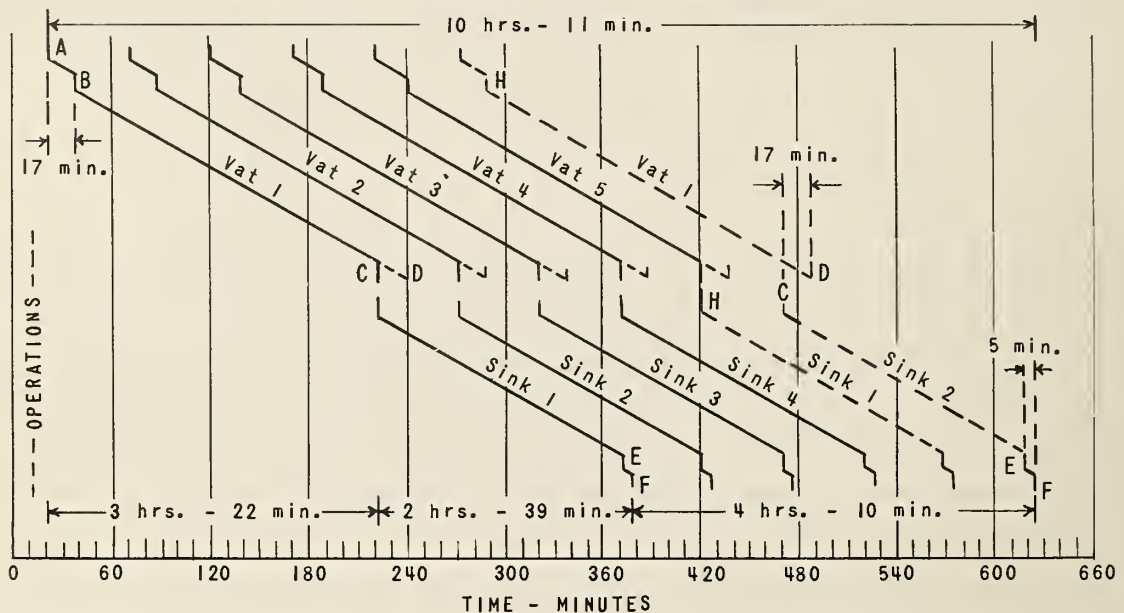
With the regular method, 9 cheese vats would be needed before the first one could be re-used in continuous operation. With the pump and curd sink method, 5 vats and 4 curd sinks would be used to make 6 or more lots of cheddar cheese. The 50-minute interval between filling vats is based on a 12,000-pound-per-hour pasteurizer continuously filling 10,000-pound cheese vats.

FIGURE 1
TIME REQUIRED TO MAKE CHEDDAR CHEESE, USING
50 MINUTE INTERVALS BETWEEN FILLING VATS

A. COMPLETE PROCESS IN 10,000 POUND CHEESE VATS



B. CHEESE VAT FOR COAGULATION AND CURD SINKS FOR SUBSEQUENT
PROCESSING; CORRECTED FOR 10,000 POUND CHEESE VATS



A - Start milk to vat
B - Add starter
C - Start draining
D - Vat drained and rinsed
E - Finish hooping

F - Rinsing curd sink or vat
G - Extra vats necessary for
continuous operation
H - First re-use of equipment

According to information obtained from a manufacturer of cheese making equipment, a vat holding 10,000 pounds of milk costs about \$3,000; a curd sink \$2,500; and a pump \$600. On the basis of these figures a plant would need to produce the equivalent of between 8 and 9 vats of cheese, or cheese from 80,000 to 90,000 pounds of milk daily, to justify the use of curd sinks and a pump in terms of investment.

The relative importance of these cost items in operating plants of different sizes by the regular and the curd sink methods is shown in table 4. If these estimates are correct, it would appear that the curd sink method might be practical in a plant with a capacity of 60,000 pounds or more of milk per day. For smaller plants, the regular vat system would be more economical. A 7 percent saving in labor cost would not be sufficient to offset the additional investment for the extra equipment. However, for a capacity of 9 vats or more, the equipment would cost less for the curd sink method than for the regular method.

A 10,000-pound cheese vat requires 170.4 square feet of floor space including a working space 15 inches wide around it. A curd sink for this size vat requires 96.2 square feet, including working space. Eight regular vats would, therefore, require less floor area than 5 vats and 4 curd sinks. Beyond this number of vats and sinks, the curd sink method would require less space than the regular method for equal volumes of milk.

The pounds of cheddar cheese produced per cheese room employee varies widely in plants over the country. Labor efficiency depends in part upon the quality and fat content of the milk, size of vats, number of vats, plant layout, maintaining proper temperature in the vats, and moisture content of the cheese produced. Duties of the cheese room crew also may vary as to whether the cheese is pliofilm wrapped or paraffin dipped. Some authorities feel that a crew equivalent to one man per 10,000-pound cheese vat making cheddar cheese should be sufficient under favorable conditions. Judging from these opinions and actual observations, one man's time and about a fourth of the time of another man per vat in manufacturing cheddar cheese in modern plants would be a reasonable estimate. This figure will be used as a basis for calculating conventional method labor costs in comparing the several methods of manufacturing cheese.

The curd sink method probably would reduce the number of employees needed per unit of production. Since no plant is known to make 10,000-pound lots of cheddar cheese with the curd sink and pump method, and no work schedules are available, data cannot be used to substantiate this conclusion. On the basis of a shorter over-all period of time for making a batch of cheese with the curd sink method, only about 93 percent as much labor is required as for the regular cheddar cheese making process.

Table 4. - Estimated investment in equipment and major operating expense for regular cheddar cheese manufacturing compared with manufacturing in vats and curd sinks

Figure	1 (A)	1 (B)	1 (A)	1 (B)	1 (A)	1 (B)	1 (A)	1 (B)
Pounds of milk processed per day-----	60,000		70,000		80,000		90,000	
Investment-----	6 vats 5 vats 4 sinks 1 pump	5 vats 4 sinks 1 pump	7 vats 5 vats 4 sinks 1 pump	8 vats 5 vats 4 sinks 1 vat	9 vats 5 vats 4 sinks 1 vat	10,000 10,000 600	15,000 15,000 10,000 600	27,000 27,000 15,000 10,000 600
Vats at \$3,000-----	\$18,000	\$15,000	\$21,000	\$15,000	\$24,000	\$15,000	\$27,000	\$15,000
Sinks at \$2,500-----		10,000		10,000		10,000		10,000
Pump at \$600-----		600		600		600		600
Total equipment-----	18,000	25,600	21,000	25,600	24,000	25,600	27,000	25,600
Floor area at \$5 per sq. ft.-----	5,112	6,199	5,964	6,199	6,816	6,199	7,668	6,199
Operating cost items								
10% depreciation equipment-----	1,800.00	2,560.00	2,100.00	2,560.00	2,400.00	2,560.00	2,700.00	2,560.00
3% depreciation floor area-----	153.36	185.97	178.92	185.97	204.48	185.97	230.04	185.97
Labor 365-8 hr. days at \$1.00 per hour based on 1.25 men per cheese vat-----	21,900.00	20,367.00 ¹	25,550.00	23,761.50 ¹	29,200.00	27,156.00 ¹	32,850.00	30,550.50 ¹
Total major operating expense-----	23,853.36	23,112.97	27,828.92	26,507.47	31,804.48	29,901.97	35,780.04	33,306.47

¹Based on 93 percent of labor cost of making cheddar cheese in regular conventional cheese vats.

MAKING GRANULAR CHEESE

Granular cheese has been made in this country but the practice was discontinued many years ago. Hand rakes were used to keep the curd in granular form, but later were replaced by power driven agitators. Curd sinks also have been used in making granular cheese. Recently there has been renewed interest in this method of making granular cheese but difficulties have been experienced in obtaining a product of uniform quality.

The experiments conducted on granular cheese making were carried out primarily to determine what effect pumping has on the quality of curd and what possibilities this method has in saving labor and facilities. No attempts were made to maintain a uniform quality product. In doing the work it was recognized that granular cheese differs slightly from cheddar cheese in appearance, texture, and taste. Also, there are no grades for granular cheese.

In making granular cheese the same procedure is followed in coagulating the milk in the vat as with cheddar cheese. In conducting the experiments, the cheese maker used the same techniques in observing the progress and condition of the curd as he used in making cheddar cheese. When the biological phase was completed, the curd together with the whey was pumped to a curd sink. The curd was agitated in the sink mechanically but was not milled. The hooping and pressing operations were the same as for cheddar cheese.

During the pumping of the curd and whey into the curd sink, the overhead agitating forked stirrer was in motion, stirring and distributing the curd granules over the perforated bottom of the sink tray. The major part of the whey was separated from the curd granules as they were discharged from the pump into the sink.

The stirring agitator for the curd sink consists of a set of tines welded into the cross arm of each stirrer and offset in such a manner that as the four arms revolve, each tine forms a separate arc and all curd granules are reached. Each cross arm has a hinged shovel or shoe attached to its end for the purpose of moving curd from edges of the sink to prevent matting. Square-end sinks must have semi-circular guards attached to the ends of perforated drain trays, formed to the same radius as that of the stirring shoe. Unless these guards are provided, the cheese maker must move the curd by hand from all four corners to prevent matting. Round end sinks are manufactured to conform to the radius of forking shoes. Agitators are kept in motion most of the time granules are in the curd sink. However, this stirring may be stopped temporarily to permit granules to mat slightly.

Because of the rapid draining facilities of the perforated bottom of the draining tray, whey is constantly drained from curd granules as the forking agitators invert the granules. This action is the principal reason that the period of time required to drain is less than for making cheddar cheese in a regular vat.

The daily work schedule for the several lots of granular cheese made in experimental vats is shown in table 5. Table 6 shows the average of all

Table 5. - Daily work schedule for experimental vat in making granular cheese

Experimental lot numbers	10050 ¹	10180	10190	10200	10210	10230	10240	10250
Weight of whole milk (pounds)-----	9,700	900	900	875	875	875	875	875
Acidity and percent fat of milk-----	.17	3.5	3.4	3.5	.16%	3.5	3.5	3.5
Pasteurizing temperature and exposure (seconds)-----	166°	16	163°	16	163°	16	163°	16
Acidity and quality of starter-----	.86	G	.82	G	.76	G	.80	G
OPERATIONS								
Time and pounds of starter added-----	8.00	7.15	7.10	7.20	6.55	7.10	7.15	7.10
Time and ounces of color added-----	8.40	12	7.55	1	7.35	1	7.53	1
Time and ounces of rennet added-----	8.50	29	8.10	3	7.50	3	8.05	3
Temperature and acidity of milk when rennet added-----	88°	.17	88°	.17%	.88°	.17%	.88°	.17%
Time and acidity of milk at cutting curd-----	9.20	.12	8.40	.12	8.21	.12	8.40	.12
Time and acidity of milk at steam on-----	9.35	.12	8.55	.12	8.35	.12	8.45	.12
Time and acidity of milk at steam off-----	10.05	.12	9.24	.13%	9.19	.13	9.15	.13%
Temperature of milk at steam off-----	102°	100°	100°	102°	100°	100°	100°	100°
Time and acidity of milk at draining curd-----	11.05	.14	10.15	.16	10.29	.16%	10.26	.16%
Time and temperature of curd in curd sink when pumping was completed-----	11.18	98°	10.10	98°	10.34	98°	10.43	93°
Time and pounds of salt added-----	11.42	25	10.48	2%	11.05	2%	11.13	2%
Temperature and acidity of curd at salt added-----	0	.25	92°	.26	86°	.26	92°	.26%
Time start hooping curd-----	11.47	-	11.00	-	11.20	-	11.16	-
Temperature and acidity of curd at hooping-----	92°	.27	90°	.26%	85°	.26	84°	.28%
Time hoops put in first press-----	12.03	-	11.05	-	11.24	-	11.22	-
Time hoops dressed-----	12.30	-	11.28	-	11.44	-	11.45	-
Time hoops put in last press-----	12.46	-	11.35	-	11.58	-	12.00	-
Total time of above operations-----	4'-46"	4'-20"	4'-48"	4'-40"	4'-38"	4'-15"	4'-25"	4'-35"
Pounds cheese made-----		81#-1 oz.	84#-5 oz.	81#-9 oz.	83#-10 oz.	81#-15 oz.	81#-2 oz.	85#-14 oz.
Percent fat in cheese in 24 hours-----		32	32.5	32	32.5	33	33	32
Percent moisture in cheese in 24 hours-----	No record	37.7	38.7	38.8	39.2	37.2	38.3	39.2
Percent fat in dry matter in 24 hours-----		51.4	53	52.3	53.5	52.5	53.5	52.6

Table 5* - Daily work schedule for experimental vat in making granular cheese - continued

Experimental lot numbers	10270	10280	11020	01121	01131	01171	01181	01191
Weight of whole milk (pounds)-----	800	900	900	800	800	775	850	900
Acidity and percent fat of milk-----	.15% 3.4	3.5	.15% 3.5	.16	.16	.20 3.5	.16 3.5	.16 3.5
Pasteurizing temperature and exposure (seconds)-----	163° 16	163° 16	163° 16	163° 16	163° 16	163° 16	163° 16	163° 16
Acidity and quality of starter-----	.80 G	.85 G	.71 G	.76 G	.77 G	.76 G	.76 G	.74 G
OPERATIONS								
Time and pounds of starter added-----	7.10 11½	7.05 11½	7.10 9½	7.40 7½	8.05 8	7.47 12	7.55 12	7.40 12
Time and ounces of color added-----	7.50 1	7.40 1	7.57 1	7.55 ¾	8.45 ¾	8.15 ¾	8.40 1	8.30 1
Time and ounces of rennet added-----	8.01 3	8.00 3	8.10 3	8.05 2½	8.50 2½	8.21 3	8.46 18	8.35 3
Temperature and acidity of milk when rennet added-----	88° .17	88° .17	88° .17	88° .18	86° .18	86° .23	88° .18%	87° .18
Time and acidity of milk at cutting curd-----	8.31 .12	8.31 .11½	8.41 .11½	8.36 .11½	9.15 .12	8.33 .15	9.02 .12	9.00 .12
Time and acidity of milk at steam on-----	8.45 .12	8.45 .12	8.55 .12	8.50 .12	9.31 .12½	8.47 .15	9.20 .13	9.15 .12
Time and acidity of milk at steam off-----	9.14 .13½	9.16 .13	9.25 .12½	9.21 .12½	9.46 .12½	9.12 .15%	9.35 .13	9.35 .12½
Temperature of milk at steam off-----	102°	100°	100°	100°	99°	100°	100°	99°
Time and acidity of milk at draining curd-----	10.32 .19	10.35 .16½	10.40 .14½	10.05 .13	12.29 .17½	10.10 .16	11.10 .14	10.50 .15
Time and temperature of curd in curd sink when pumping was completed-----	10.36 100°	10.39 96°	10.43 94°	10.12 96°	12.36 93°	10.15 92°	11.18 97°	10.57 96°
Time and pounds of salt added-----	11.59 3	11.58 3	12.35 2½	10.55 2½	1.00 2½	11.00 2½	12.25 3	11.30 3
Temperature and acidity of curd at salt added-----	98° .33	94° .37%	96° .39	92° .16	90° .22	98° .22	98° .28	98° .27
Time start hooping curd-----	12.19 -	12.05 -	12.40 -	11.10 -	1.10 -	11.20 -	12.40 -	11.58 -
Temperature and acidity of curd at hooping-----	98° .39%	92° .38	96° .39	- .17	90° .22	98° .25	98° .30	99° .27
Time hoops put in first press-----	12.24 -	12.08 -	12.50 -	11.20 -	1.15 -	11.45 -	12.50 -	12.10 -
Time hoops dressed-----	12.29 -	12.17 -	1.00 -	11.40 -	1.25 -	12.05 -	1.05 -	12.25 -
Time hoops put in last press-----	12.34 -	12.20 -	1.05 -	11.50 -	1.30 -	12.10 -	1.10 -	12.30 -
Total time of above operations-----	5'-24"	5'-15"	5'-55"	4'-10"	5'-25"	4'-23"	5'-15"	4'-50"
Pounds cheese made-----	81½-12 oz.	82½-7 oz.	82½-13 oz.	75½-7 oz.	81½-3 oz.	78½-11 oz.	78½-2 oz.	79½-5 oz.
Percent fat in cheese in 24 hours-----	33.5	33.8	32	31	33.5	32	34.5	34.5
Percent moisture in cheese in 24 hours-----	34.7	35.8	34.8	41.7	37.5	35.8	36	35.4
Percent fat in dry matter in 24 hours-----	52.8	52.2	49.1	53.1	53.6	49.6	53.9	53.4

*This large lot was produced in a commercial plant and the observed data are included here to permit comparison with the small lots produced in the experimental vat.

Note: Symbol (') indicate hours and (") minutes.

Table 6. - *Average of time schedules for 15 experimental lots of granular cheese made in curd sinks shown in table 5, and adjustment for 10,000-pound curd sinks*

Biological process for phase 1 from table 1	3 hours 5 minutes	3 hours 5 minutes
Mechanical process phase 2		Mechanical process phase 2
Operations	Average process time of granular cheese in 1000 lb. experimental sinks	Adjusted time for process in 10,000 lb. sinks
Start draining vat-----	10.39 a.m.	10.39 a.m.
Finish draining vat-----	10.41	10.51
Adding salt-----	11.34	11.44
Start hooping-----	11.49	11.53
Finish hooping-----	11.52	12.03
Time for phase 2-----	1 hour 13.min	1 hour 24 min.
Pressing process for phase 3		
Finish hooping-----	11.52	12.03
Hoops in 1st press-----	11.54	12.13
Dressing hoops-----	12.08	12.43
Hoops in last press-----	12.17	1.03
Time for phase 3-----	0 hours 25 min.	1 hour 0 min.
Total time for all phases---	4 hours 43 min.	5 hours 29 min.

these operations and the adjustment for manufacturing in 10,000-pound capacity sinks. Since the 15 lots of granular cheese were experimental, the average of these operations shown does not represent standard practice. Many experiments made were delayed in order to ascertain what results would be obtained from the changes made.

Modern measuring pumps are available to handle up to 60,000 pounds of milk per hour. These pumps have adjustable speed regulators that adapt capacities to meet requirements. Table 6 shows a period of 12 minutes in which curd and whey are pumped from the 10,000-pound cheese vat into the curd sink. A period of 5 minutes was required to empty the 1,000-pound experimental vats, using a 12,000-pound pump. Comparing the total time required for manufacturing cheddar cheese of 7 hours and 25 minutes (table 1) with 5 hours and 29 minutes required for a 10,000-pound granular cheese operation (table 6), it follows that the granular cheese operation requires about 74 percent as much manufacturing time as the conventional cheddar cheese operation.

The continuous operation for manufacturing 6 or more 10,000-pound lots of granular cheese, using 5 cheese vats and 2 curd sinks, is illustrated in figure 2. Allowances have been made for a 17-minute period to partially fill cheese vats with milk before starter is added, 12 minutes for emptying cheese vat, and 5 minutes for rinsing cheese vat and curd sink preparatory to reusing each as shown in figure 1. These allowances are included in the 3-hour and 22-minute biological time and the 1 hour and 29 minute mechanical time shown.

The interval between the time the cheese maker starts to fill one vat and the time he starts to fill the next, and the capacities of vats, will determine the size of pasteurizer and the number of vats and sinks that must be installed for a continuous flow of milk to make 6 or more lots of cheese before the first vat or sink and succeeding vats or sinks can be rinsed and ready to use again. These relationships are shown in table 7.

Table 7. - *Relation of vat filling intervals to capacity of continuous pasteurizer and number of 10,000-pound cheese vats and curd sinks necessary to produce 6 or more lots of cheese*

Vat filling intervals	Continuous pasteurizer capacity per hour	Number required:	
		Cheese vats	Curd sinks
30 min.....	20,000 pounds of milk	8	4
40 min.....	15,000 pounds of milk	6	3
50 min.....	12,000 pounds of milk	5	2
60 min.....	10,000 pounds of milk	4	2

Referring to table 7, five vats and 2 curd sinks would be needed for manufacturing 6 or more lots of granular cheese with 50-minute filling intervals. While a period of 9 hours would be required in which vats and sinks are in use, individual manual operations are staggered so that the required manual jobs can be done with a minimum of confusion.

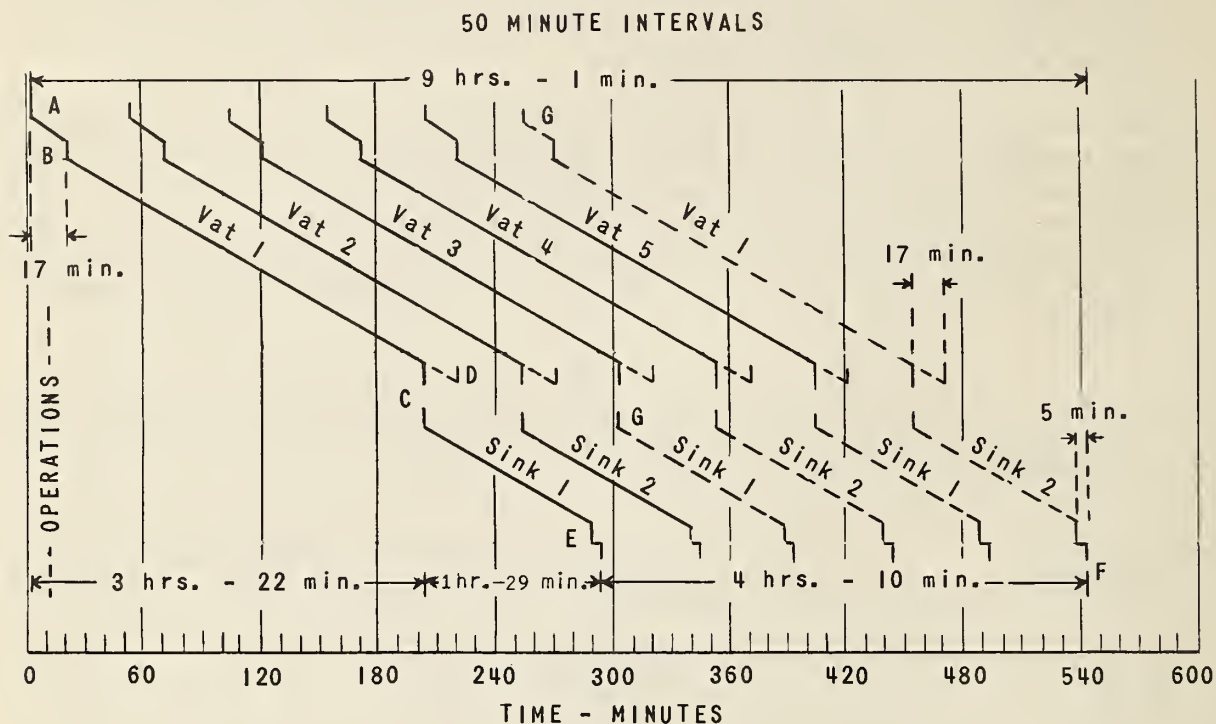
Making cheddar cheese required manual labor for cheddaring and milling curd. These operations are not required in making granular cheese. One man can perform all the necessary operations in draining, salting, and getting the curd ready to hoop.

Comparing over-all time shown in figure 1 (A) of 10 hours and 57 minutes with over-all time shown in figure 2 of 9 hours and 1 minute, granular cheese making requires about only 82 percent of the time required for making conventional cheddar cheese.

The over-all time shown on figures 1 and 2 does not include the time required to set up machinery; remove hoops from presses; wash machinery, hoops, or pipes; and other work necessary to keep the cheese factory clean and sanitary. However, the labor required for cheddaring and

FIGURE 2

NUMBER OF VATS AND CURD SINKS NEEDED TO MAKE 6 OR MORE LOTS OF GRANULAR CHEESE USING 50 MINUTE INTERVALS BETWEEN FILLING VATS



A - Start milk to vat
 B - Add starter
 C - Start draining
 D - Vat drained and rinsed

E - Finish hooping
 F - Rinsing curd sink or vat
 G - First re-use of equipment

milling cheese from 6 vats that is not required for granular cheese making can be utilized for other services, thus possibly reducing labor requirements to less than 82 percent.

The investment, facilities, and major cost items of the three methods of manufacturing cheese discussed in this report are summarized in table 8. According to these estimates, there is little difference in cost between the conventional method and the curd sink method of making cheddar cheese in a plant handling 60,000 pounds of milk daily in 6 vats. The granular

Table 8. - *Estimated investment in equipment and floor area for making cheese from 60,000 pounds of milk daily, conventional cheddar cheese in vats, cheddar cheese in vats and sinks, and granular cheese in vats and sinks.*

Item	Conventional cheddar cheese in vats	Cheddar cheese in vats and sinks	Granular cheese in vats and sinks
Vats-----	\$18,000	\$15,000	\$15,000
Sink-----	--	10,000	5,000
Pump-----	--	600	600
Major machinery investment	18,000	25,600	20,600
Floor area at \$5 sq. ft.--	5,112	6,199	5,230
10% depreciation machinery	1,800	2,560	2,060
3% depreciation floor area	153.36	185.97	157.05
Labor for 365--8-hour days @ \$1 per hour-----	21,900	20,367 ¹	17,958 ²
Total operating expense---	\$23,853.36	\$23,114.97	\$20,175.05

¹Based on 93 percent of labor cost of making cheddar cheese in conventional cheese vats.

²Based on 82 percent of labor cost of making cheddar cheese in conventional cheese vats.

cheese method would be considerably cheaper than the conventional or the curd sink method of making cheddar cheese. An increase in capacity beyond 60,000 pounds per day would favor both new methods.

Based on the average of the experimental granular cheese manufacturing operations, the time of not more than 5 and one-half men would be required for the cheese room of a plant daily making granular cheese from 60,000 pounds of milk in 10,000-pound vats and curd sinks.

As the daily number of 10,000 vats of cheese made is increased, labor efficiency also will be increased. However, comparing the differences in over-all time (figures 1 and 2) for the two methods of making cheddar cheese, the granular method will require about 82 percent as much time as the regular cheese method. Therefore, the labor requirements for granular cheese shown on table 8 are based on 82 percent of 7.5 men or 6 men per day.

With a 50-minute interval for filling successive vats, five 10,000-pound vats and two curd sinks will be needed. As previously stated, the vats cost \$3,000 each and curd sinks \$2,500 each and the pump \$600. With a

floor area of 170.4 square feet for each vat, and 96.2 square feet for each sink, the cheese room area would approximate 1,045 square feet. Structures of the type commonly used for cheese making are estimated to cost about \$5 per square foot of floor area.

While the coagulation process for granular cheese is identical with that of cheddar cheese, and the mechanical process very similar, the reason for the difference in flavor in both cheeses has not been determined. When the granular cheese was removed from hoops 24 hours after being put into presses, the body contained many minute openings, and in some instances the outlines of granules were apparent. To determine whether greater pressure was required in the presses, a small metal cylinder was filled with granules and pressed for 24 hours in a bench vise. The actual pressure could not be determined but possibly 150 percent more pressure was developed than is usually applied in standard cheese presses for cheddar cheese. This sample was stored in a 60° F. room for a week and then placed in a kitchen electric refrigerator for 5 months. Upon examination this sample closely resembled cheddar cheese in appearance, but had the typical granular cheese flavor.

Several samples of granular cheese made at different times were kept in an electric refrigerator for several months. Upon comparing the body appearance with the appearance of the same cheese when originally taken from presses, it was noticeable that granules had knitted and very few openings were found at the end of the 5-month period. The change in flavor, however, was not noticeable.

Another sample of granular cheese, in the form of a twenty-pound block, was stored in a commercial type cold room at 40° F. for a period of over 13 months. The flavor of this sample had changed appreciably during the months in storage and resembles that of cheddar cheese of comparable age.

While this study was confined to pumping curd and the use of curd sinks in making cheddar and granular cheese, there are other savings possible in labor expense at many plants. Considerable labor is required for trucking cheese from presses to wrapping and curing rooms, especially in large plants, and for trucking hoops to hand washing sinks. Savings in labor can be made by using conveyors and an automatic hoopwasher. The latter would not require an attendant and would deliver clean hoops back to the curd sinks for refilling immediately after they were emptied. In some existing plants, equipment should be rearranged for greatest economy.

The floor plan of a hypothetical plant designed for use of curd sinks is given in figure 2. An automatic hoopwasher is shown even though such a machine is not now available commercially. Also illustrated is a milk thawing device which is sometimes used in cold climates. In preparing the plan, efforts were made to centralize related operations by arranging equipment and rooms in ways that minimize manual transportation of curd and cheese.

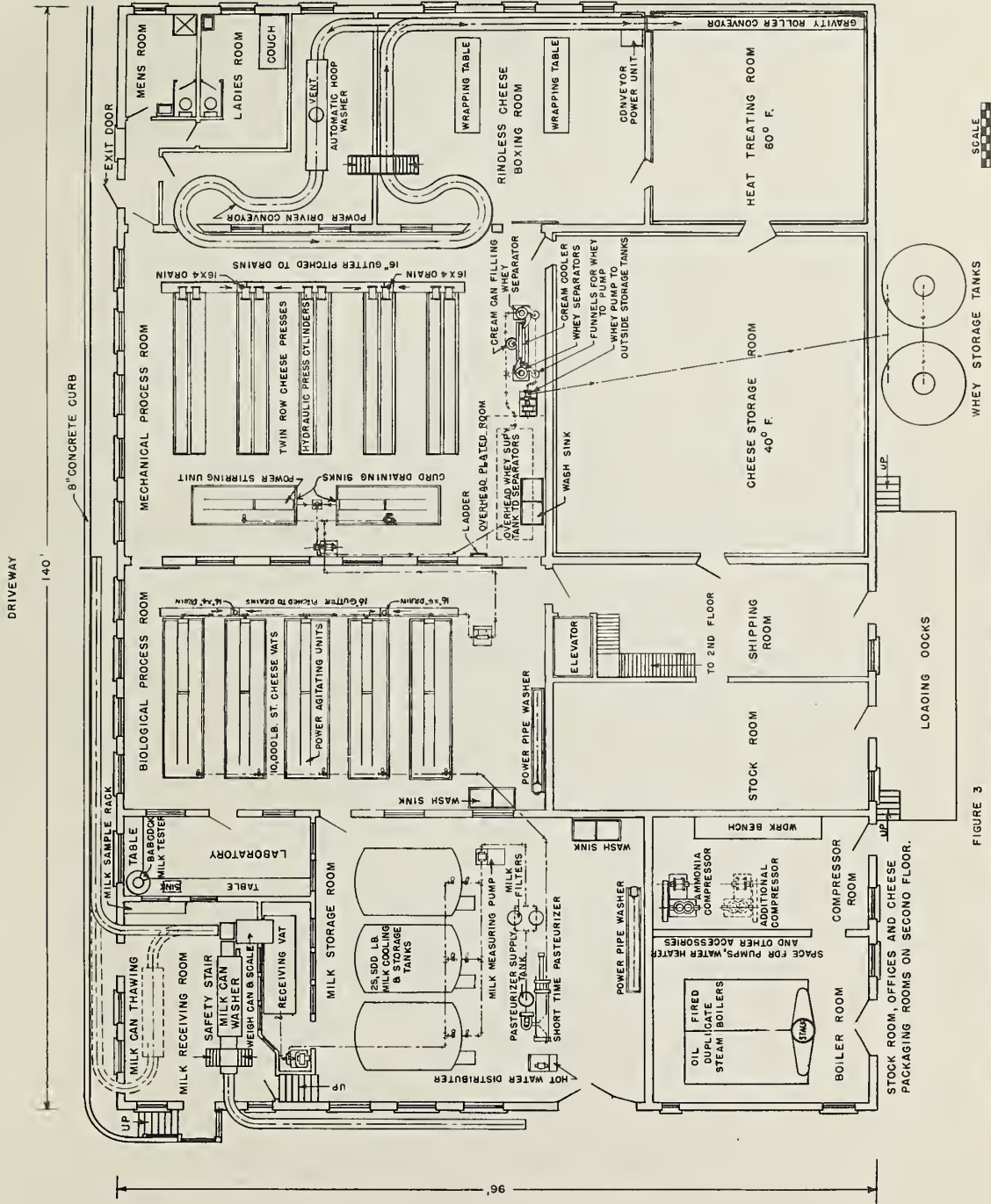


FIGURE 3

SUGGESTED LAYOUT FOR CHEESE PLANT USING THE PUMPED CURD SYSTEM FOR HANDLING 100,000 POUNDS OF MILK DAILY

